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ABSTRACT

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Influences on Academic Achievement Across High and Low Income Countries: A Re-Analysis of IEA Data

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June, 1980

This analysis has been undertaken as part of the World Bank's research project on "Textbook Availability and Educational Quality," RPO 671-60, and the Education Department's research project on "The Influence of School Resources". The data were acquired with the kind assistance of Edward Kifer at the University of Kentucky. The views and interpretations however are solely those of the authors and, in particular, do not necessarily reflect the views of the World Bank.

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ABSTRACT

Previous international studies of science achievement put the data through a process of winnowing to decide which variables to keep in the final regressions. Variables were allowed to enter the final regressions if they met a minimum beta coefficient criterion of 0.05 averaged across rich and poor countries alike. The criterion was an average across all countries because the original idea was to identify those variables which were thought to be "important" across all societies taken together. The question is whether this process tended to omit school variables which may have had strong effects within one country but not across the average of many countries. We have re-entered variables for each country separately, using the same minimum entry criterion of 0.05 as before, but within each country separately. Using only variables which have been found to be "important" in that particular society, we get different results, and the changes are of two sorts: they tend to significantly increase the variance explained by school effects, and this increase tends to be greatest in the "poorer" countries.

The IEA

The International Association for the Evaluation of Educational Achievement (IEA) was organized in 1958 and housed within the UNESCO Institute of Education with two basic purposes. One was to develop internationally valid evaluation instruments which "conceived of the world as one big educational laboratory where a great variety of practices in terms of school structure and curricula were tried out" (Comber and Keeves, 1973: 10). The second was to design a survey of educational facilities and practices as they existed in this world "laboratory" and go beyond the purely descriptive aspects to identify those particular characteristics in curriculum, pedagogy, and school physical facilities which might explain why some students perform better than others (Husen, 1979).

The task was ambitious. Material from which the IEA could draw conclusions was as large as had ever been previously acquired in the Social Sciences. Three hundred experts, representing 20 countries and 14 languages, participated in the design, validation, and administration of the instruments. By 1973 the IEA had gathered data on a representative sample of 10,000 schools, 50,000 school teachers, and had recorded test scores in six subjects on approximately 260,000 students at age 10, 14, and at the fourth year of secondary school. 1/ These data included approximately 500 independent variables, many of them potentially maniputable by policy. Forty-five questionnaire items alone referred to either the opportunity to read, or the amount of reading materials available. The influence of any of them could have been

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1/ An in-depth discussion of sampling and test design can be found in Thorndike (1973) and Purves (1973).

analyzed in three separate age groups in as many as 21 countries and against all six subjects tested. Between two and three thousand correlation (or regression) coefficients could have emerged just to gauge, for example, the influence of reading on student achievement. Clearly some strategy had to be designed by which the number and variety of coefficients could be narrowed down to manageable portions. Thus the first task which faced the IEA studies was how to choose what to analyze.

Data Reduction

At the time there was very little precedent from which one could draw experience. The IEA was the first attempt to predict the effect of schools and student background across countries. Though, originally, the IEA studies were designed prior to methodological breakthroughs of the Coleman and Plowden Reports, still the analyses of IEA data were strongly influenced by the desire to test the same questions and techniques about school vs. home which these earlier published reports had pursued so creatively and which touched off such intensive debate. 2/ Curiosity about the impact of school quality in the aggregate, and the understandable need for speed and efficiency, together acted to determine the manner by which the IEA studies proceeded to reduce the amount of data. The procedure decided

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2/ The Coleman Report was published in 1966 and the Plowden Report in 1967. The "official" nine volumes of the IEA Six Subject Survey were published between 1973 and 1976.

upon was basically a three step process. 3/ First, student background variables were selected (in a between student analysis) if they attained a correlation coefficient (with achievement) which was larger than twice their standard error. Second, the effects of these student background variables and the type of school program 4/ were partialed out and the other predictor variables were entered into a regression with Science, Reading Comprehension and Literature Scores. The resulting standardized regression (beta) coefficient was noted for each variable. Third, when this beta coefficient averaged across all 18 countries in the sample exceeded 0.05, the variable was then selected for inclusion in the later analyses (Comber and Keeves, 1973:245) 5/. This last step proved to be the most critical. In order to be included in the final pool, a variable — such as the Number of Science Teachers per School, for example — had to be a sizable predictor of science achievement in Germany as well as in India.

3/ The process for the selection of variables was not as well documented as it could have been. In some instances variables were kept if they were "favorite sons"; and slight variations may also have occurred from one age group to the next. The three step process is, in general, a fair characterization of Population II (14 year olds) achievement in science.

4/ Grammar vs comprehensive schools for example.

5/ Twenty different countries participated in the IEA survey; 19 in the Science Achievement Survey; and 18 in the Population II Science Achievement Survey. Israel and France were the two countries not participating in the Population II sampling. Since we will be discussing the Population II in the Science Survey exclusively, we will usually refer to the number of participating countries as 18.

The IEA Conclusions

Initial conclusions based upon the international sample of IEA countries roughly parallel those of previous single nation studies, in particular the Equality of Educational Opportunity Study of the United States (Coleman, et.al., 1966) and the Plowden Study of the United Kingdom (Children and their Primary Schools, 1967; Peaker, 1971). Higher academic performance is commonly associated with children from privileged economic backgrounds (Thorndike 1975), and the sum total of this influence — a summary measure of parental education, occupational prestige, and other indicators of Home Circumstances — is somewhat larger than the sum total of influence resulting from the measured effects of school and teacher quality. 6/ In one re-analysis of IEA data however, the generalizability of this conclusion was questioned. It was shown that the association between "pre-school influences" and academic achievement diminished in linear fashion with the national per capita income of the countries in the IEA sample - the poorer the country the weaker the associations (Heyneman, 1976; 1980). 7/

6/ Achievement in French and English as a foreign language were sometimes exceptions to this tendency.

7/ Pre-school influences consist of Home Circumstances, age, and sex — characteristics over which the school has no control. The influence of Home Circumstances is positively associated with national per capita income whether or not it is combined with the other pre-school variables.

Unanswered Questions

If preschool influences in the IEA study are only marginal in low income IEA countries (Iran, Chile, India and Thailand), 8/ then conversely, should not the influence of School Quality be higher? Negative correlations have emerged between national per capita income, for example, and the impact of school and teacher quality on student achievement [r=-.04 (with total variance); r=-.41 (within the explained variance)], 9/ but neither correlation coefficient was statistically significant. Consequently the case for there being systematically higher school effects in the low income IEA countries has never been quite as conclusive as the case of systematically lower pre-school effects.

One of the unanswered questions pertaining to this issue is whether too many variables — particularly those measuring school quality — were eliminated from the regressions in Iran, Thailand, Chile and India because the average regression coefficients for them were less than the agreed-upon 0.05 value averaged across all 18 countries in the IEA sample. Was it

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8/ All countries in the IEA sample, except for India, Chile, Thailand and Iran, will be described as "high income countries".

9/ The impact of school quality is being measured in two ways. One is the familiar R^2, the proportion of achievement variance explained by school quality (which is then correlated with per capita income). The second is the percentage within the R^2 due to school quality. Though this latter method poses some headaches in terminology, it does allow for the comparison of a particular block of variables across studies in different countries where the size of the R^2 might differ substantially.

possible that some variables with strong influences on science achievement were eliminated in low income countries because those same variables had less effect on achievement in high income countries?

IEA Science Achievement: A Reanalysis

We have approached this question by re-submitting the IEA raw data to a new process of selection (see Appendix A). Instead of requiring a minimum regression coefficient averaged across all countries, our procedure has been to submit each potential influence to the same test of importance, but in each country separately. This process is somewhat more arduous. It has analyzed all significant school and teacher variables which predict science achievement in Germany for example; and these have then been placed on a final list to be entered in a regression as an aggregated block of School Quality for Germany alone. The same process was applied to the United States, to India, Sweden, and to each of the 18 countries in the IEA Population II science sample. Thus what we have is a new list of variables with regression coefficients greater than 0.05. Unlike the earlier IEA analyses which used the same list of school quality variable in all countries, our list is quite dis-similar from one country to the next; a measure of school or teacher quality, strong in one locale, in no way determines its strength elsewhere.

The complete list of variables included in the final IEA regressions was never published. What was published was a list of ten "selected" variables, used uniformly. Our revised lists are considerably longer. In India for example, in addition to the original ten, we found 23 school and teacher variables which had regression coefficients of greater than 0.05; in Chile we found 16 variables, and in Germany we found another 14 variables with this level of achievement impact.

Results of the Analysis

As in the original IEA studies, we forced pre-school influences into the regression first; then school variables last. The effect of entering the new list of school variables is quite pronounced. 10/ In five countries the total amount of variance which can be explained declines by some amount; but the overall effect is for more variance to be explained (Table 1). 11/ For Hungary the total amount of variance explained rises from 22 to 28%; in Italy from 21 to 23%; and in the USA from 30 to 35%. Taking all countries together the total amount of variance explained by the earlier regressions was 30.8%; in the re-analyses it is 33.2%. (Table 1).

TABLE 1 about here

10/ Our listings for home circumstances and other ascriptive characteristics mirror those of Comber and Keeves. In one or two instances we deleted a variable when we found that it contained insufficient variance. Sibling size -- because of inconsistent signs -- was not inserted in the block for home circumstances. Otherwise the pre-school block in every country was identical to that of Comber and Keeves both in construction and in the way it was entered into our regressions.

11/ Thailand was the only low income country in which the total amount of variance explained (R^2) declined. This decrease was attributable entirely to preschool and school track. In England the R^2 decline was substantial (47% to 39%), but again, was attributable to preschool, school track and program variables.

Second, The bulk of this increase can be attributed to the increases in variance explained within the four low income countries in the IEA sample. The increase in variance explained for industrialized countries was approximatly 4.0%; for low income countries it was 20.0%. 12/ Third, the lower level of achievement variance explained in the original IEA estimates is primarily due to a systematic underestimate of the effects of school and teacher quality; and this pertains to both low and high income countries. In high income countries the new list of School Quality variables increases the level of variance explained by 38% (from 6.5% to 9.0%). In low income countries the differences are quite a bit more pronounced; there the portion of science achievement explained by School Quality jumps from 11.5% to a new estimate of 20.8%. This is an increase of about 80%.

Nevertheless there are substantial differences in the degree to which the effects of school and teacher quality characteristics were underestimated in earlier regressions. The revised lists of variables measuring school and teacher quality have made a substantial difference in the results from Italy, Hungary, Chile and India but have had only a moderate impact on the results from Thailand; and very little impact at all on the results from Iran. In Hungary the percentage of variance explained by teacher and school quality has increased from 5.0 to 13.0%. In Italy it increased from 6

12/ A fairly substantial amount of the 4.0% increase in variance explained in industrialized countries is due to the results from Italy and Hungary.

to 13%. 13/ To our knowledge this makes Italy the first example of an industrialized country in which the effects of school quality appear to outweigh the effects of home background and other pre-school influences. Nevertheless, in both India and Chile the change is even more evident. As a result of the revised list of variables, in both of those countries the impact of school and teacher quality increases by approximately a multiple of three — from 6.0% to

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13/ The Italian sample contains one anomoly. Population II was supposed to contain 14 year olds; but in Italy 7% of this sample was either over or under age by an excess of two years. If one were to consider Population II in Italy as an undifferentiated unit and not select out this 7%, the proportion of variance attributable to school effects would rise above our figure of 13% to a higher estimate of 18%. Our more conservative estimate is attenuated because we restricted the Population II sample in Italy to 15 years or younger.

20% in Chile, and from 8.0% to 28% in India. 14/ Furthermore, of the variance in science achievement which can be explained in Chile, 59% is attributable to school and teacher quality; and in India, 90% is attributable to school and teacher quality. The statistical effect of school and teacher quality is higher in India than in any other country in the world on which we have data.

Whatever the reason for the lack of significant change in the school effect estimates for Thailand and Iran, these exceptions do not seem to counter what we suspected; namely that the impact of school quality in low income IEA countries was artificially attenuated by the way variables were origin-

14/ The difference between the original (8%) and the revised (28%) estimates for the effect of schools in India deserves some explanation. Ninety-one percent of the students in the India sample had been enrolled in an academic track with an emphasis upon courses in the social sciences and humanities. This variable (school program) originally explained 10% of the achievement variance -- in addition to the 8% explained by school and teacher quality. We have omitted this school program variable from our regressions because we felt that the distribution (91 vs. 9) constituted an inappropriate level of invariance. Thus 10% of the Comber & Keeves variance in achievement due to school "program" might now be explained by "school and teacher quality". This would, if true, alter the estimate from 8% to 18%. Our estimate is 28%. We submit that our higher figure is due not just to the reassignment of school program to the School Quality Block, but also to the exclusion of additional school physical facilities and teacher quality variables from the earlier regressions.

ally chosen for the regressions. When the impact of the revised figures for the impact of School Quality is re-correlated with per capita income, the coefficients jump both in size and in statistical significance. Previous figures ($r = -.05$ and $-.41$), are now superceded by stronger levels of negative association [$r = -.37$, $p < .05$ (with total variance); and $r = -.67$, $p < .001$ (within the explained variance)]. 15/ This lends confidence to what we could not be as sure of before -- that the poorer the country the more impact of School Quality.

Conclusion

It is not our intent to imply that the directors of the IEA studies errored in choosing their methods of data reduction or in their analysis. They were faced with very recalcitrant problems of data management and the techniques which they devised have, by and large, set a high standard of quality for future cross-national research efforts. Nevertheless, future IEA and -- other international educational evaluations -- will increasingly focus on those countries which were left out of previous analyses, countries in Africa, Latin America, Asia, and The Middle East. When contemplating the manner by which these new studies should be conducted it might be wise to incorporate the lessons from the past. One of them should be to not limit one's concern to

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15/ As in the original correlations with per capita income, results from the Primary School Quality Project in Uganda have been entered here along with the results of the IEA studies. This allows for five low income countries instead of the original four in the IEA sample. For the differences and similarities between the IEA and Ugandan data sets, see (Heyneman, 1976; and Heyneman and Jamison, 1980).

just those variables which are "important" across all societies; for if we do we will miss seeing inter-societal differences of significance. Rather, a recommended approach would be to follow the one explored here -- variables should be allowed to enter the final regressions if they meet a minimum entry criterion for each individual country. This technique is indeed more cumbersome, but to not apply it may seriously underestimate the level of influence of those characteristics which are not highly inter-correlated with one another, namely, the elements of school and teacher quality.

The search for school characteristics -- alterable by policy -- which influence school achievement will likely have no single resolution. Elements of schools and teachers which deserve investment differ from one country to the next. This complexity should be no surprise; nor should it be a handicap to research. 16/ The complexity of disentangling the impact of these various school and teacher qualities in each country separately should not prevent us from incorporating the lessons of these IEA analyses of school and teacher quality "blocked" in the aggregate. Despite the current ambiguity in many high income countries as to whether the impact of school quality on academic achievement makes "no difference", or whether it makes a marginal, or major difference, no such ambiguity exists in low income countries. The fact is that when data on school and teacher characteristics are allowed to express

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16/ The World Bank's Research Committee, through RPO671-60, is sponsoring research of this kind in 16 low income countries: Egypt, Iran, Thailand, India, Chile, Uganda, Paraguay, Mexico, Philippines, Colombia, Bolivia, Brazil, El Salvador, Peru, Argentina and Botswana.

the full measure of impact in their country of origin, these characteristics in low income countries can explain between two and three times the level of achievement variance that they can in high income countries; and the poorer the country in economic terms the more impact on achievement school quality and teachers seem to have.

APPENDIX A

Treatment of Missing Cases

There is no way of knowing from published sources how Comber and Keeves treated missing cases in their analysis. We used pairwise rather than listwise deletion of missing cases, [See Kim and Curry (1977), for a discussion on the best procedure]. In some instances where the number of missing cases was not excessive, we substituted sample mean values in their place. By doing so, we kept the overall N value respectably close to the total sample size. This would not have been possible had we employed listwise deletion techniques. In running both pair and listwise regression equations however, we find that the former procedure yields, on average, lower R^2 values. From this we conclude that the pairwise analysis reported in this paper represents an error in the direction of a small, conservative (e.g., downward) bias when estimating achievement variance.

In addition, while it is true that we were handling close to 30 school variables at a time in each regression run (i.e., with some 450 correlations holding the potential for yielding matrix singularity) it is also true that our large sample sizes (in the thousands) mitigated against such an occurrence. The ratio of degrees of freedom, a comparison of variables entering the equation with sample size, always exceeded 1:10. The 1:10 ratio is generally considered the absolute minimum limit, below which regressions should not be performed.

Initial Cleaning and Re-Coding

Variables were removed from consideration in any country if: (a) they were badly skewed (i.e.: if they had little or no variance), or

(b) if missing cases exceeded 25%. In this we were slightly less conservative than Comber and Keeves, who used a limit of 20%. Also, in some cases where a variable was trichotomized initially, if there seemed to be too few cases in the lower or upper category, we took the liberty of creating a dichotomy.

Data Reduction

School variables were selected for inclusion in each country's regression equation in the following way: First, after controlling for preschool variables, we determined whether or not each school variable, taken separately, had a significant impact on achievement of (beta) .05 or better. All school variables meeting this statistical criterion were then placed together and subjected to a stepwise regression analysis for each nation. The result was a new list containing considerably more variables than did the list of ten selected school variables reported by Comber and Keeves (1973:206). This new list of variables was then entered in the regressions for each country separately and its effects compared with the effects of preschool, school track and/or school program influences.

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TABLE 1

PERCENTAGE OF SCIENCE ACHIEVEMENT EXPLAINED BY FOUR GROUPS OF VARIABLES IN 18 IEA COUNTRIES: ORIGINAL AND REVISED ESTIMATES[a]

COUNTRY (Ranked by GNP Per Capita 1971.)	PRESCHOOL VARIABLES		SCHOOL TRACK		SCHOOL PROGRAM		SCHOOL VARIABLES		TOTAL EXPLAINED	
	Original	Revised	Original	Revised	Original	Revised	Original	Revised	Original	Revised
India	(3)	2.7	(0)	0	(10)	.5	(8)	28	(21)	31
Thailand	(9)	6	(3)	0	(-)	-	(23)	26	(35)	32
Iran	(5)	8	(1)	0	(-)	-	(9)	9	(15)	17
Chile	(13)	8	(4)	6	(-)	-	(6)	20	(23)	34
Hungary	(14)	14	(0)	0	(3)	1	(5)	13	(22)	28
Italy	(11)	8	(2)	2	(2)	0	(6)	13	(21)	23
Japan	(23)	21	(-)	-	(-)	-	(4)	9	(27)	30
England	(23)	20	(15)	4	(2)	0	(7)	15	(47)	39
Scotland	(28)	29	(1)	0	(9)	10	(9)	14	(47)	53
New Zealand	(17)	22	(-)	-	(12)	10	(8)	9	(37)	41
Netherlands	(19)	22	(-)	-	(15)	9	(10)	11	(44)	42
Finland	(22)	20	(0)	1	(6)	4	(10)	9	(38)	34
Australia	(16)	17	(1)	0	(7)	8	(11)	7	(35)	32
Flemish Belgium	(8)	12	(2)	2	(-)	-	(12)	16	(23)	30
French Belgium	(-)	20	-	2	-	-	-	13	-	35
Germany	(18)	17	(2)	5	(-)	-	(14)	14	(34)	36
Sweden	(18)	19	(-)	-	(-)	-	(7)	6	(25)	25
USA	(21)	21	(-)	-	(2)	1.5	(7)	12.5	(30)	35
Average (Mean)	(15.8)	15.9	(1.8)	1.2	(4.0)	2.4	(9.2)	13.6	(30.6)	33.2

a/ Original estimates derived from Comber and Keeves (1973) in which variables were entered only if they had attained a minimum beta coefficient of .05 across all countries in the sample. Revised estimates were calculated by allowing any variable to enter if it obtained a minimum beta coefficient of .05 within the country under consideration. French-speaking Belgium was not included in the published results from Comber and Keeves and therefore is represented by dashes here. All other dashes indicate that a variable was not a relevant factor for the country in question.